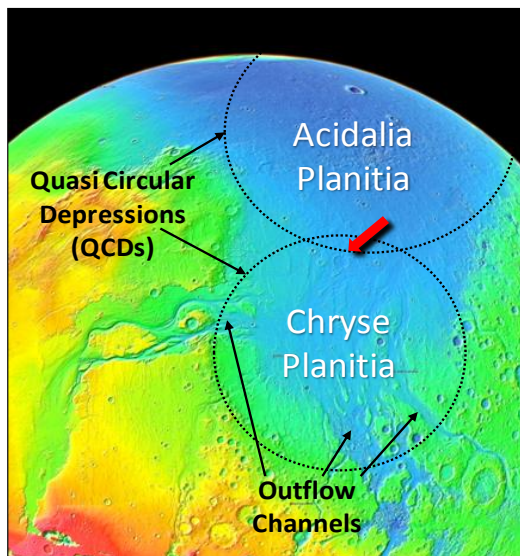


**Introduction:** Habitability assessments are critical for identifying settings in which potential biosignatures could exist in quantities large enough to be detected by rovers. Habitability depends on 1) the potential for long-lived liquid water, 2) conditions affording protection from surface processes destructive to organic biomolecules, and 3) a source of renewing nutrients and energy. Of these criteria, the latter is often overlooked. Here we present an analysis of a large “ghost” crater in northern Chryse Planitia [1] that appears to have satisfied each of these requirements, with several processes providing potential sources of nutrient/energy renewal [1-2]. This analysis can serve as a model for identifying other localities that could provide similarly favorable settings in which to seek evidence of life on Mars.

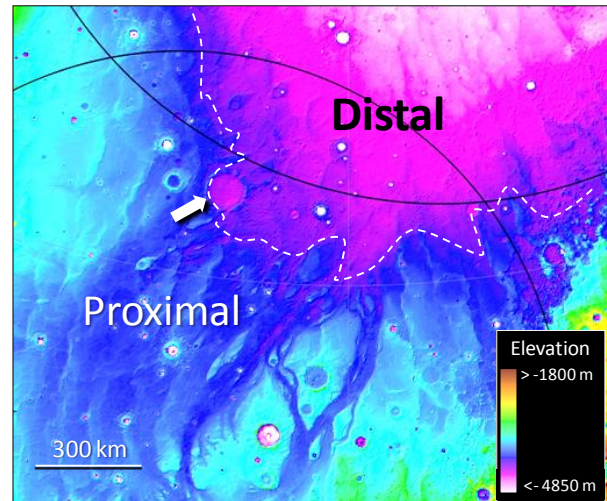
**Crater Description and Geologic Setting:** A 120 km-diameter crater in northern Chryse Planitia (centered at 34°N, 37°W) is located in the path of major outflows from the Hesperian floods (Fig. 1). It is also



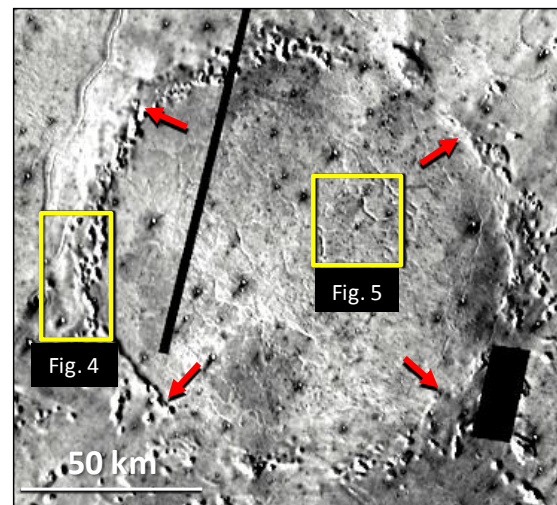
**Fig. 1.** Regional setting of ghost crater. MOLA basemap (courtesy of Google Mars). Quasi-Circular Depressions (QCDs) [3]. Arrow points to ghost crater.

located within an approximate zone of predicted, fine-grained, distal-facies sediments from the outflow floods (Fig. 2) [4]. This crater is filled with sediment and its rim is subdued as if partially eroded (Fig. 3). This type of crater has been termed a “ghost” or “stealth” crater.

The rim of the crater is defined by large (1.5-4 km-diameter), variably-shaped knobs with rounded bases (Fig. 4). The crater fill is characterized by polygonally fractured material that is associated with hundreds of



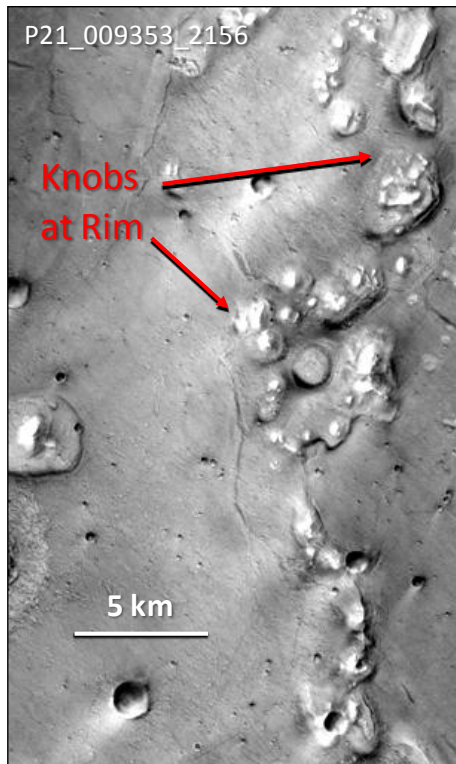
**Fig. 2.** Predicted facies. Stretched MOLA basemap. Black arcs are portions of Chryse & Acidalia QCDs [3]. White arrow points to ghost crater. Dashed line shows approximate boundary between proximal and distal facies.



**Fig. 3.** Ghost Crater. THEMIS Daytime IR basemap. Rectangles show areas of Figs. 4 and 5. Arrows point to subdued rim.

smaller (0.4-0.9 km-diameter), high-albedo, circular mounds (Fig. 5).

**Discussion:** The large size of this crater and its location combine to provide especially favorable conditions for habitability. The crater diameter (> 100 km) is in the range suggested to result in significant impact-related hydrothermal circulation [5-7]. The rounded knobs at the crater rim would be consistent with that possibility. The crater sits in the lowlands, where upwelling of late Noachian/early Hesperian ground waters has been suggested from hydrologic

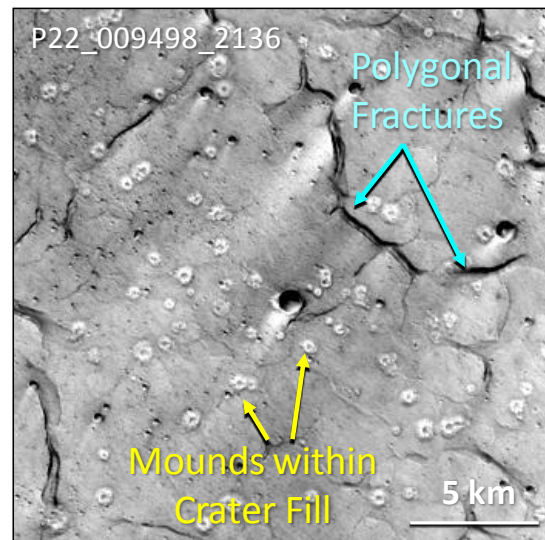


**Fig. 4.** Context Camera (CTX) image of the crater rim illustrating rounded knobs. Location shown on Fig. 3.

modeling [8]. Such upwelling could have contributed to fluid flow up the impact-related fractures, providing a renewing source of nutrients for potential life in the crater. The crater is also located in the path of the Hesperian floods (Fig. 1), and a crater lake could have filled from combined hydrothermal activity, upwelling, and fluvial runoff. It has been proposed that hydrothermal circulation in martian craters > 50 km in diameter would be sufficient to keep crater lakes from freezing for thousands of years [5]. A lake in this crater, therefore, might have been long-lived.

The location of the crater within the predicted distal facies of outflow sedimentation (Fig. 2) suggests that crater-filling sediments would be fine-grained. Those sediments could have entrapped organics, as potential organic materials would have been concentrated by sedimentary processes along with the fine-grained fraction of sediments. Such fine-grained sediments could have protected organic biomolecules from destruction by processes on the surface of Mars [4].

The polygonal fractures and smaller mounds within the crater fill are suggestive of significant fluid flow within the crater. On Earth, kilometer-scale polygonal faults are often associated with fluid injections in fine-grained, marine sediments [9]. In addition, the mounds within the crater fill have been compared to terrestrial mud volcanoes [10], which would also imply processes of fluidized injection to the surface. The potential for



**Fig. 5.** CTX image of crater fill illustrating polygonal fractures and mounds. Location shown on Fig. 3.

fluid migration from the subsurface to surface - by both impact-related hydrothermal processes and fluid expulsion related to development of polygonal fractures and associated mounds - provides several opportunities for nutrient/energy renewal to potential life in the near surface or surface.

**Conclusions:** This analysis illustrates the importance of geologic context in evaluating habitability. Because of the size and geologic setting of this crater, fluid activity and possibly a crater lake could have been relatively long-lived, possibly existing from the time of initial impact to the time of polygon- and mound-formation. Nutrient and energy renewal could have been provided by fluid flow associated with development of the polygonal fractures and mounds as well as by upwelling and impact-related circulation. Burial of either *in-situ* or transported biosignatures in the predicted fine-grained fill could have aided preservation of organic biomarkers.

This is the type of location with enhanced habitability, where potential life might have thrived. It is also a location where organic biomarkers of that life could have been both concentrated and preserved.

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